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IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF:	:
SABURO WAKITA ET AL	: EXAMINER:
SERIAL NO. : NEW APPLICATION	:
FILED: HEREWITH	: GROUP ART UNIT:
FOR: MOLD FOR PRODUCING SILICON INGOT AND METHOD FOR FABRICATING THE SAME	: :

PRELIMINARY AMENDMENT

ASSISTANT COMMISSIONER FOR PATENTS
WASHINGTON, D.C. 20231

SIR:

Preliminary to an action on the merits of this case, please amend this application as follows.

IN THE CLAIMS

Please cancel all claims present in the case, i.e., Claims 1-21, and substitute the following Claims 22-29 in their place.

22. (New) A mold for producing a silicon ingot, comprising:

a graphite or quartz mold body having a bottom and a top having an opening and having an inner wall face of a shape which defines the shape of the silicon ingot produced, said inner wall face coated with a silica layer containing a fine fused silica sand having a particle size of 100-300 μm.

23. (New) The mold according to Claim 22, wherein the inner wall face of said mold is tapered from the bottom of the mold towards said opening so that the area of the opening

becomes larger than the area of the bottom of the mold.

24. (New) The mold according to Claim 22, wherein the interior of the mold has a circular or a polygonal horizontal cross-section which defines the shape of the silicon ingot product produced.

25. (New) The mold according to Claim 23, wherein the interior of the mold has a circular or a polygonal horizontal cross-section which defines the shape of the silicon ingot product produced.

26. (New) A mold for producing a silicon ingot, comprising:

a graphite or quartz mold body having a bottom and a top having an opening and having an inner wall face of a shape which defines the shape of the silicon ingot produced, the interior wall face of the mold coated with a silica layer containing at least one layer prepared by binding a fused silica powder with a particle size of 100 μm or less and a fine fused silica sand with a particle size of 100-300 μm with a silica binder.

27. (New) The mold according to Claim 26, wherein the inner wall face of said mold is tapered from the bottom of the mold towards said opening so that the area of the opening becomes larger than the area of the bottom of the mold.

28. (New) The mold according to Claim 26, wherein the interior of the mold has a circular or a polygonal horizontal cross-section which defines the shape of the silicon ingot product produced.

29. (New) The mold according to Claim 27, wherein the interior of the mold has a circular or a polygonal horizontal cross-section which defines the shape of the silicon ingot product produced.

IN THE SPECIFICATION

Page 1, as the first paragraph, please insert:

--This is a continuation of Application Serial No. 09/258,821 filed February 26, 1999, now allowed.--

BASIS FOR THE AMENDMENT

Claims 22 to 29 correspond to Claims 27 to 34 in the parent application.

REMARKS

In the parent application, Claims 27-34, corresponding to Claims 22 to 29 herein, were rejected under 35 U.S.C. §103 as being unpatentable over Snyder (U.S. 3,396,935). The other claims were allowed.

Reconsideration of this rejection is herewith requested.

The present invention relates to a mold for producing silicon ingots for use in the production of polycrystalline silicon ingots which are useful as silicon substrates for photovoltaic solar cells.

In the production of silicon ingots for the above stated use, it is known to provide the interior surface of the quartz or graphite mold employed, which defines the shape of a silicon ingot product produced, with a slurry of an inert coating substance such as silicon dioxide slurry, silicon carbide or the like. However, the silicon ingot obtained from such a mold is subjected to heat shrinkage when molten silicon is cooled in the quartz mold. The result of this shrinkage is that the silicon ingot is subjected to tension at the inner wall of the quartz mold thereby generating dislocations or cracks because of the inner stress of the ingot. This means that when silicon substrates are prepared from the silicon ingot for use in a photovoltaic solar cell, the silicon substrates inevitably exhibit poorer voltaic efficiency because of the cracks or dislocations which have developed in the silicon ingot obtained by the molding process. A need, therefore, continues to exist for an improved method of

molding molten silicon in a graphite or quartz mold in particular so as to produce a silicon ingot product which does not have cracks or dislocations.

In one aspect of the invention, as claimed in Claims 22-25, a mold for producing a silicon ingot is provided which comprises a quartz or silica mold body having a bottom and a top having an opening and having an inner wall face of a shape which defines the shape of the silicon ingot produced, wherein the interior wall face is provided with a silica layer containing a fine fused silica sand having a particle size of 100-300 μm.

In another embodiment of the mold of the invention, as claimed in Claims 26-29, a graphite or quartz mold body is provided which has a bottom and a top having an opening and having an inner wall face of a shape which defines the shape of the silicon ingot produced, wherein the inner face of the mold contains at least one layer prepared by binding a fused silica powder with a particle size of 100 μm or less and fine fused silica sand with a particle size of 100-300 μm with a silica binder.

In the parent application, the claims corresponding to the present claims were rejected under 35 U.S.C. §103(a) as being obvious over Snyder, U.S. Patent 3,396,935.

In this reference, mold bodies are formed of metal, as disclosed, for instance, at column 2, line 60, and as such exclude mold bodies prepared from quartz or graphite, which is an essential feature of the claims.

Snyder fails to disclose a mold body formed of graphite or quartz. Col. 4, lines 7-10, referred to by the Examiner in the parent case, reads as follows:

> The invention is not limited to use with specific mold sides or any particular metal mold bottom or to use with any particular molten metal. (emphasis added).

Clearly, thus no mold other than of a metal is contemplated, disclosed or suggested by Snyder. Such clearly is not obvious.

Further, with respect to the mold as claimed in Claims 22-25, although the reference

at column 7, lines 12-42 describes the use of a silica sol slurry containing a particulate refractory, such as obtained from a borosilicate glass or Vycor silica glass, nevertheless, the reference teaches a wide range of particle sizes for these particular glasses ranging from a fraction of a micron in size up to 500 microns in particle diameter or even greater. There is no teaching or suggestion of the specific limitation in Claims 22-25 of a silica layer formed from a fine fused silica sand having a particle size range of only 100-300 μm. This particle size is important if a mold is to be obtained for the preparation of a silicon ingot which is effectively within the scope of the present invention. The reference thus fails to teach or suggest the specific silica particle size of the present claim, nor makes them obvious.

As to the mold of the invention as claimed in Claims 26-29, Applicants note that in this embodiment of the invention, the inner surface of a graphite or quartz mold is provided with a layer of a bound fused silica powder having a particle size of 100 μm or less and a fine fused silica sand having a particle size of 100-300 μm, which mixed particle materials are bound with a silica binder. On the other hand, there is clearly no teaching or suggestion in the reference of preparing a refractory particulate layer within a graphite or quartz mold formed from silica powders of <u>two different</u> particle size ranges, one of which is 100 μm or less while the other ranges from 100-300 μm.

In summary, thus, the reference neither suggests, nor makes obvious, a mold for producing a silica ingot in which the mold body is made of graphite or quartz, only metal being disclosed to be useful for this purpose, nor of such mold having its inner wall coated with a silica layer as particularly defined by the claims having the advantageous and superior properties as compared to a graphite or quartz mold whose inner walls are coated with a silica layer, as claimed. Note, Conventional Examples 1 and 2 at pages 22 to 23 of the specification, as well as the results set forth in Table 1 at page 24 of the specification, reproduced below.

TABLE 1

Kind of mold	Stress Cracks	Residual release agent	Photovoltaic conversion efficiency (%)
Mold 1 of the present invention	None	None	14.2
Mold 2 of the present invention	None	None	13.9
Mold 3 of the present invention	None	None	14.1
Mold 4 of the present invention	None	None	13.9
Mold 5 of the present invention	None	None	14.0
Conventional graphite mold	None	Yes	12.8
Conventional quartz mold	Yes	None	14.2

It is evident from the results summarized in Table 1 that the polycrystalline silicon ingot produced by using the molds 1-5 according to the present invention had a better photovoltaic conversion efficiency then the polycrystalline silicon ingot using the conventional graphite mold. Although the polycrystalline silicon ingot produced by using the molds 1-5 according to the present invention has a photovoltaic conversion efficiency comparable to the polycrystalline silicon ingot produced by using the conventional quartz mold, using the mold 1-5 according to the present invention allows production yield of the polycrystalline ingot to be high, being free from the residual release agent.

Accordingly, an action on the merits and allowance of this application is requested.

Respectfully submitted,

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IN THE SPECIFICATION

Page 1, as the first paragraph, please insert, --This is a continuation of Application Serial No. 09/258,821 filed February 26, 1999, now allowed.--

IN THE CLAIMS

Claims 1-21 - (Canceled)

Claims 22-29 - (New)